Some toughts on the inputs from Physics

Matteo Rama,Achille Stocchi

Many sensitivity studies has to be done (probably all have to be redone sometime..) :

→ the detector is changed, the boost is changed…

→ we have still to answer to some important opened questions on how the « final » detector will be :

Do we need a forward PID ?

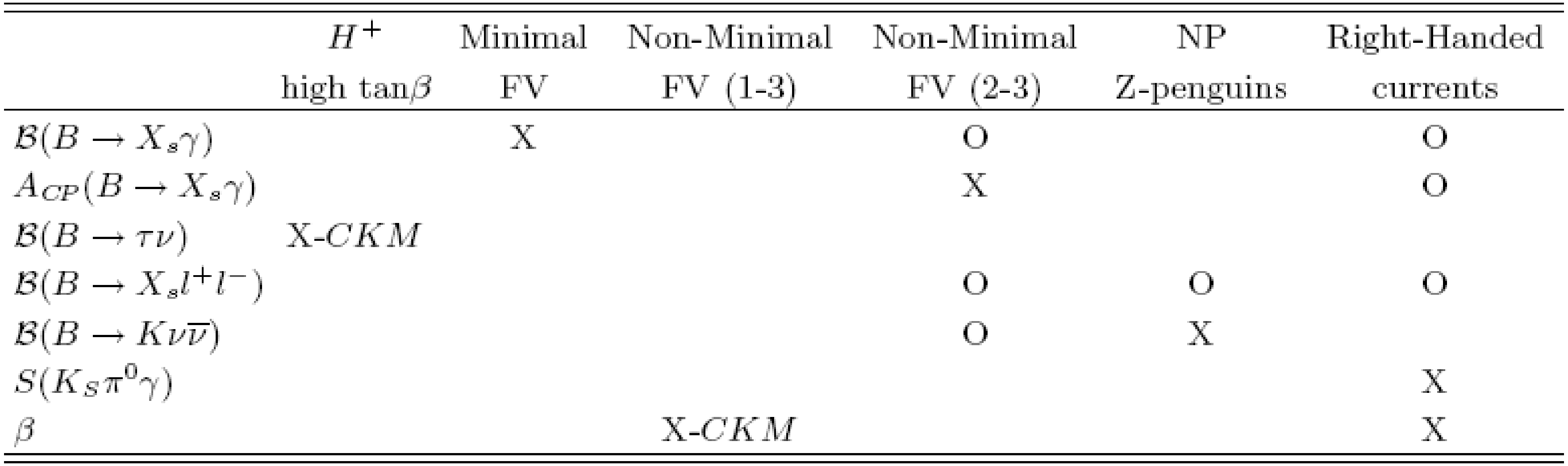
Do we need a backward EMC ?

The ammount of absorber on the IFR ?

Internal geometry of SVT / Space between SVT and DCH

Physics program is so rich that it is difficult to select a golden channel…

Nevertheless we have done the following exercise for B physics quantities :



	H^+ high tanβ	Minimal FV	Non-Minimal FV (1-3)	Non-Minimal FV (2-3)	NP Z-penguins	Right-Handed currents
$\mathcal{B}(B \to X_s\gamma)$		X		O		O
$A_{CP}(B \to X_s\gamma)$				X		O
$\mathcal{B}(B \to \tau\nu)$	X-CKM					
$\mathcal{B}(B \to X_s l^+ l^-)$				O	O	O
$\mathcal{B}(B \to K\nu\overline{\nu})$				O	X	
$S(K_S\pi^0\gamma)$						X
β			X-CKM			X

X The GOLDEN channel for the given scenario

O Not the GOLDEN channel for the given scenario but can show experimentally measurable deviations from SM.

Are they the seven magnificent ?

…adding of course τ→μγ

We could optimise on :

- $Br(B \rightarrow X_s \gamma)$
- $A_{CP} (B \rightarrow X_s \gamma)$
- $Br(B \rightarrow \tau \nu)$
- $Br(B \rightarrow X_s l\, l)$
- $Br(B \rightarrow X_s \nu \nu)$
- $S(K_s \pi^0 \gamma)$
- β
- $\tau \rightarrow \mu \gamma$

Recoil physics optimisation

K_s opimisation

K_L veto

K/π PID

μ PID and μ/π sepration

Calorimeter coverage

PID coverage

These are the golden modes for physics and also challenging ones from detector point of view !

Revisited precisions for these golden modes in Valencia meeting

Mode	Sensitivity		
	Current	10 ab^{-1}	75 ab^{-1}
$\mathcal{B}(B \to X_s\gamma)$	7%	5%	3%
$A_{CP}(B \to X_s\gamma)$	0.037	0.01	0.004–0.005
$\mathcal{B}(B^+ \to \tau^+\nu)$	30%	10%	3–4%
$\mathcal{B}(B^+ \to \mu^+\nu)$	X	20%	5–6%
$\mathcal{B}(B \to X_s l^+ l^-)$	23%	15%	4–6%
$A_{\mathrm{FB}}(B \to X_s l^+ l^-)_{s_0}$	X	30%	4–6%
$\mathcal{B}(B \to K\nu\overline{\nu})$	X	X	16–20%
$S(K_S^0\pi^0\gamma)$	0.24	0.08	0.02–0.03

Do we gain on sensitivity on

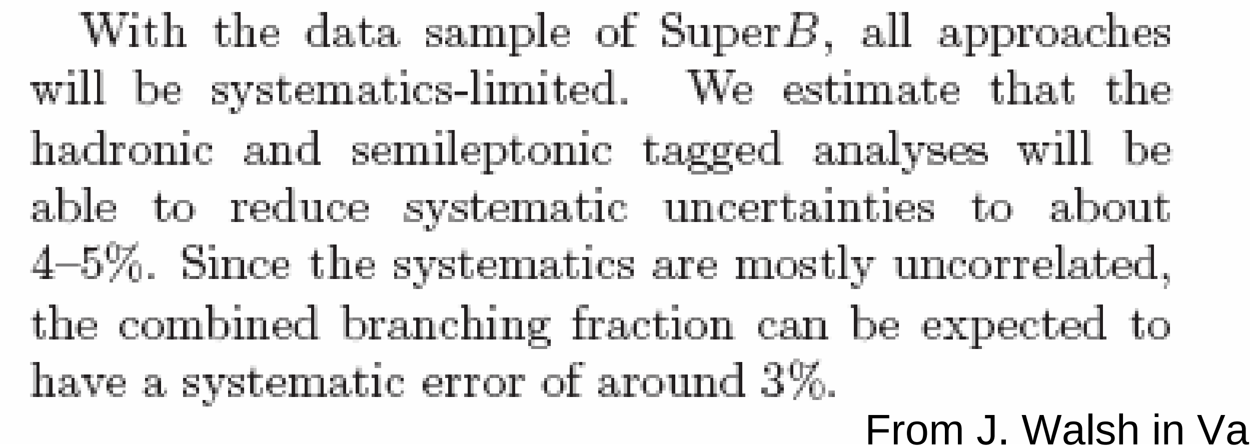
→ improving the detector (acceptance..) ?

→ by attacking what are considered
« irreducible » backgrounds

I’ll just to some extra thinking from now on…

Br($B \to s\gamma$).

In SuperB we will use recoil (semileptonic and hadronic)

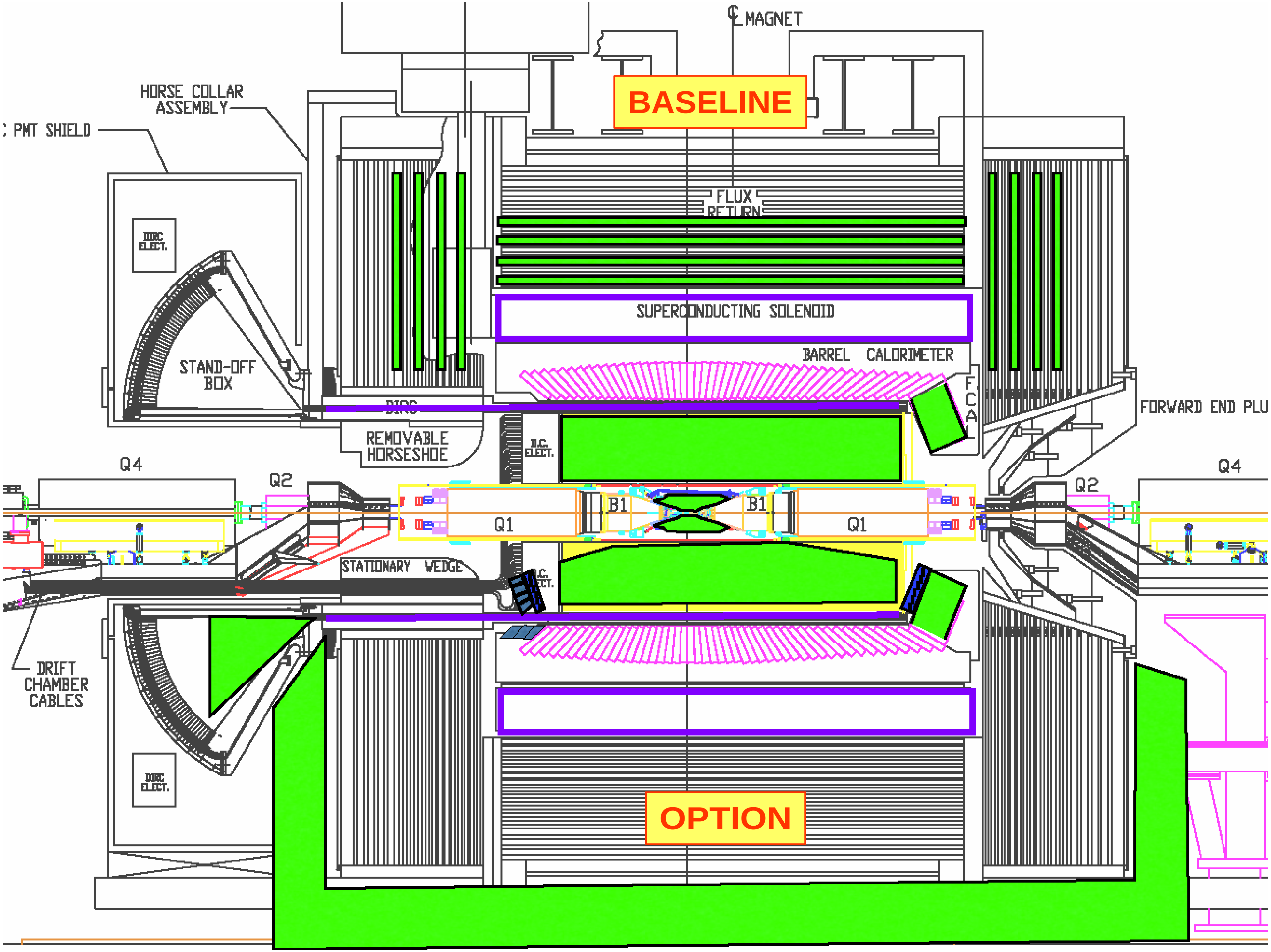


With the data sample of Super$B$, all approaches will be systematics-limited. We estimate that the hadronic and semileptonic tagged analyses will be able to reduce systematic uncertainties to about 4–5%. Since the systematics are mostly uncorrelated, the combined branching fraction can be expected to have a systematic error of around 3%.

From J. Walsh in Valencia

Many of the analyses will use recoil technique.

Improve the detector to « improve the recoil » is probably one or the crucial point.



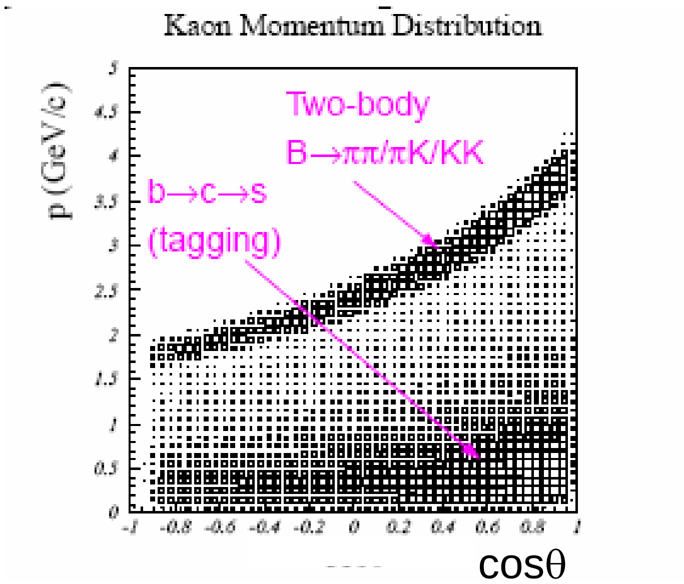
℄ MAGNET
BASELINE
HORSE COLLAR ASSEMBLY
PMT SHIELD
DIRC ELECT.
STAND-OFF BOX
FLUX RETURN
SUPERCONDUCTING SOLENOID
BARREL CALORIMETER
F C A
FORWARD END PLU
DIRC
REMOVABLE HORSESHOE
D.C. ELECT.
Q4
Q2
B1
B1
Q1
Q1
Q2
Q4
STATIONARY WEDGE
D.C. ECT.
DRIFT CHAMBER CABLES
DIRC ELECT.
OPTION

Particle identification

K/π separation

→ Flavour tagging   p<2Gev/c

→ «two body »   1.5GeV< p4Gev/c



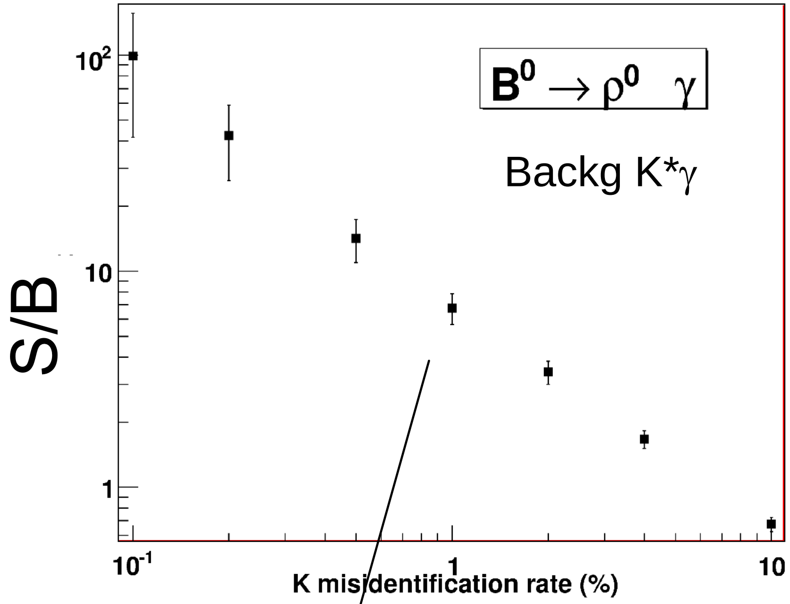
Larger coverage will be important for:

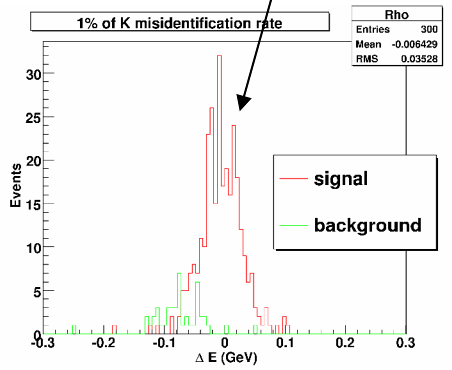
→ Tagging,
→ Recoil physics ,
→ multi-particle identification

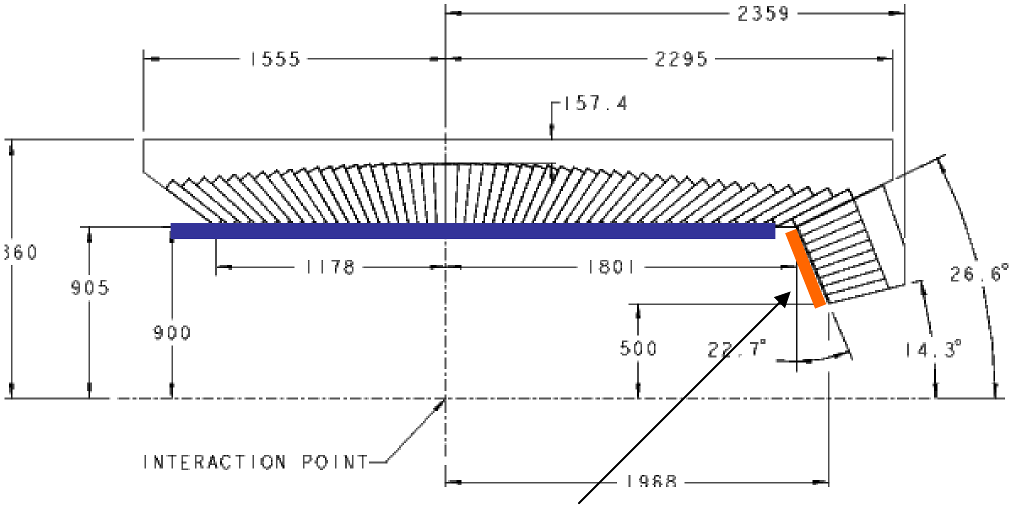
→ Probably very important in inclusive measurements
where we need good separation (multiple tracks)

ex to be studied   b→ d γ vs b→s γ

Example from Leonid talk ργ analysis considering K*γ as the only irreducible backg..







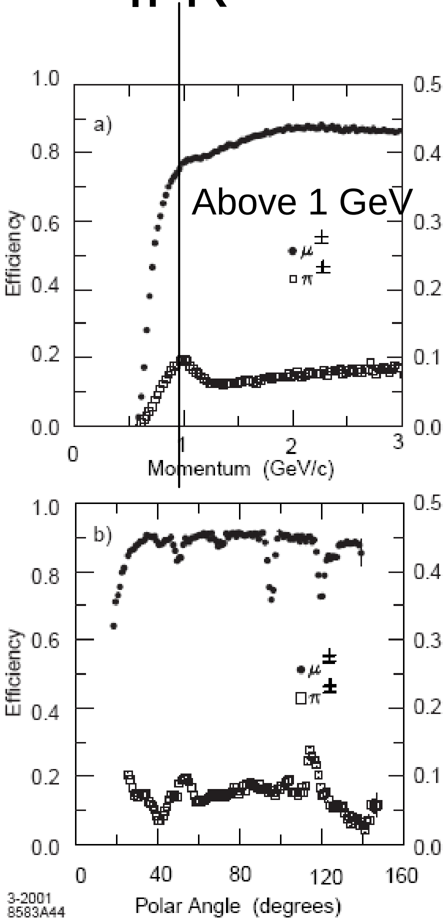
8% extra coverage

Since both tracks has to be identified
the gain is in fact larger and « preliminarly »
estimated to an effective increase of
<u>13%</u> of events

Need 1% misid. for tracks with
momentum 1<p<4GeV/c

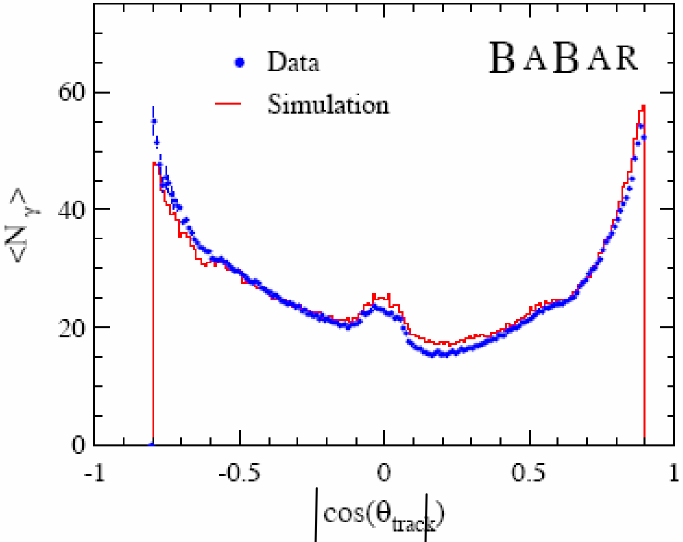
μ/π separation

IFR

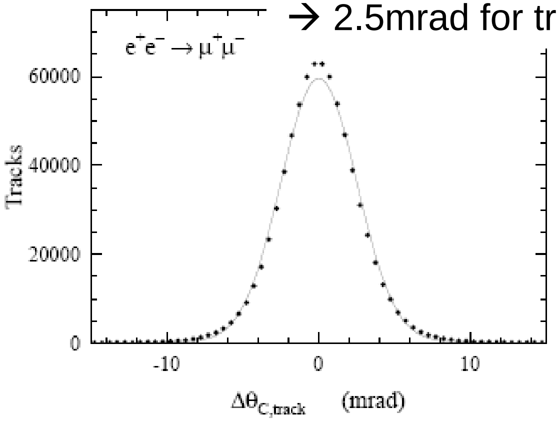


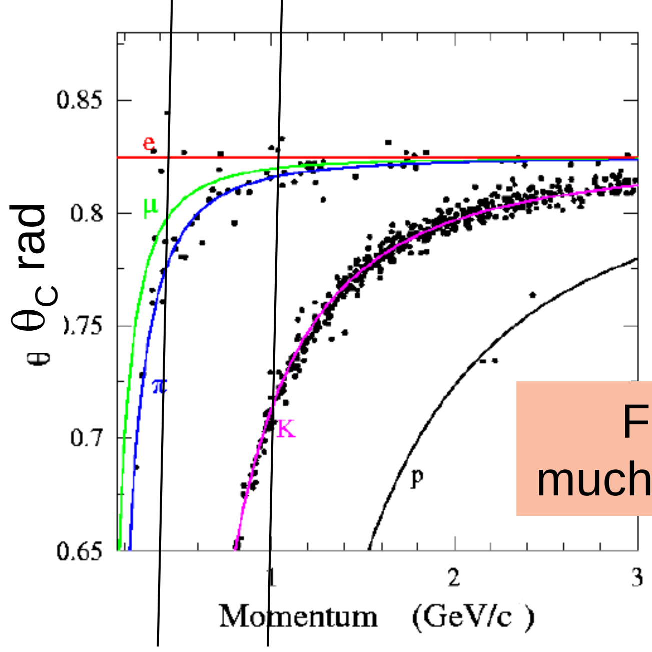
igure 79. Muon efficiency (left scale) and pion nisidentification probability (right scale) as a unction of a) the laboratory track momentum, ınd b) the polar angle (for $1.5 < p < 3.0$ GeV/c nomentum), obtained with loose selection crite-ia.

DIRC



Resolution on sigle photon is ~10mrad
→ 2.5mrad for track

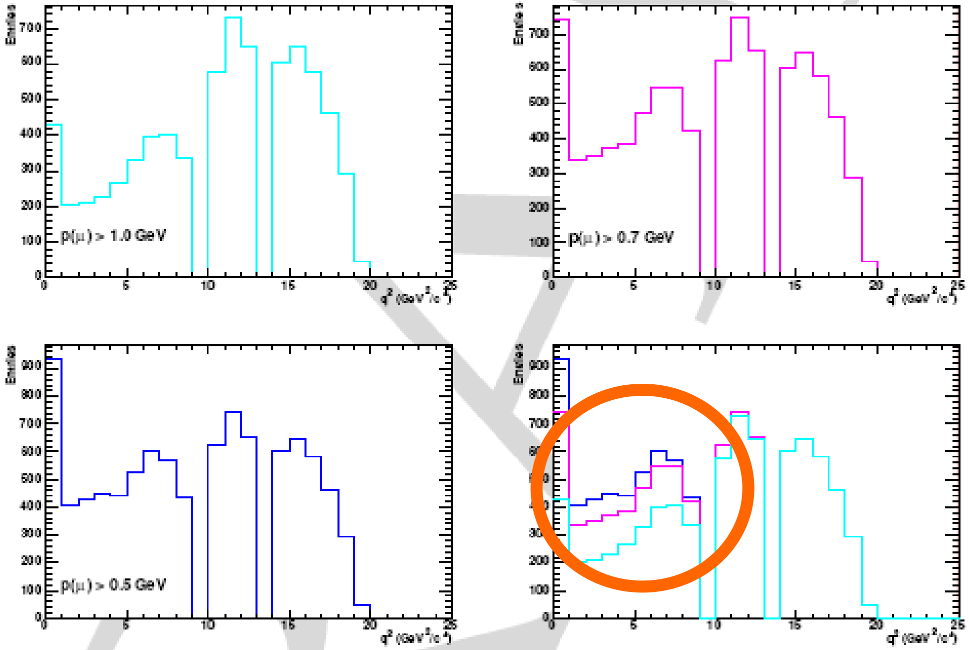




Possible for DIRC
for μ 0.4<p<1GeV/c

Focussing DIRC with
much better time resolution ?

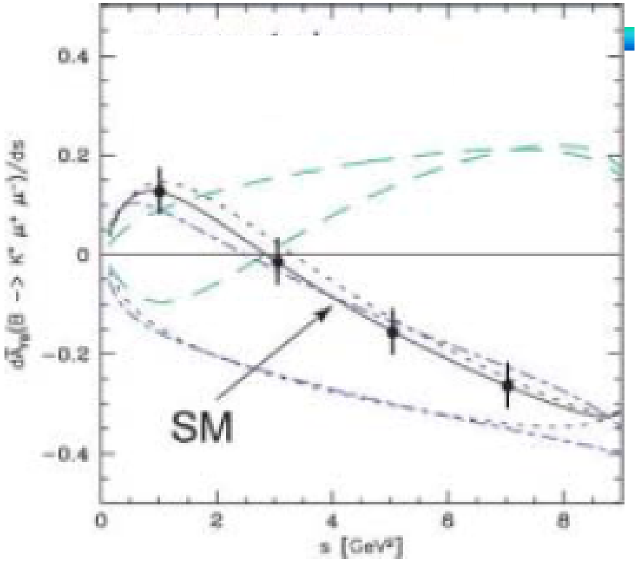
Example of physics case for m/π separation at low momentum



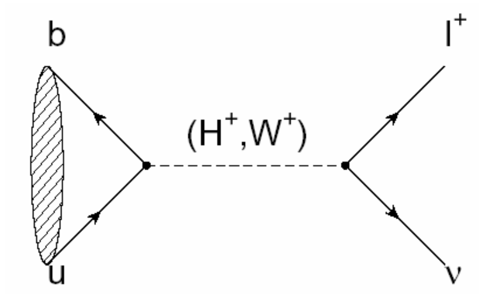
q^2=M^2 (ll)

Done in Belle. We can have a double of the events at low q^2=M^2 (ll)

AFB vs q^2



Important impact on for instance on AFB
→Zero point is at low q^2=M^2 (ll)
→ NP models differ also at low q^2



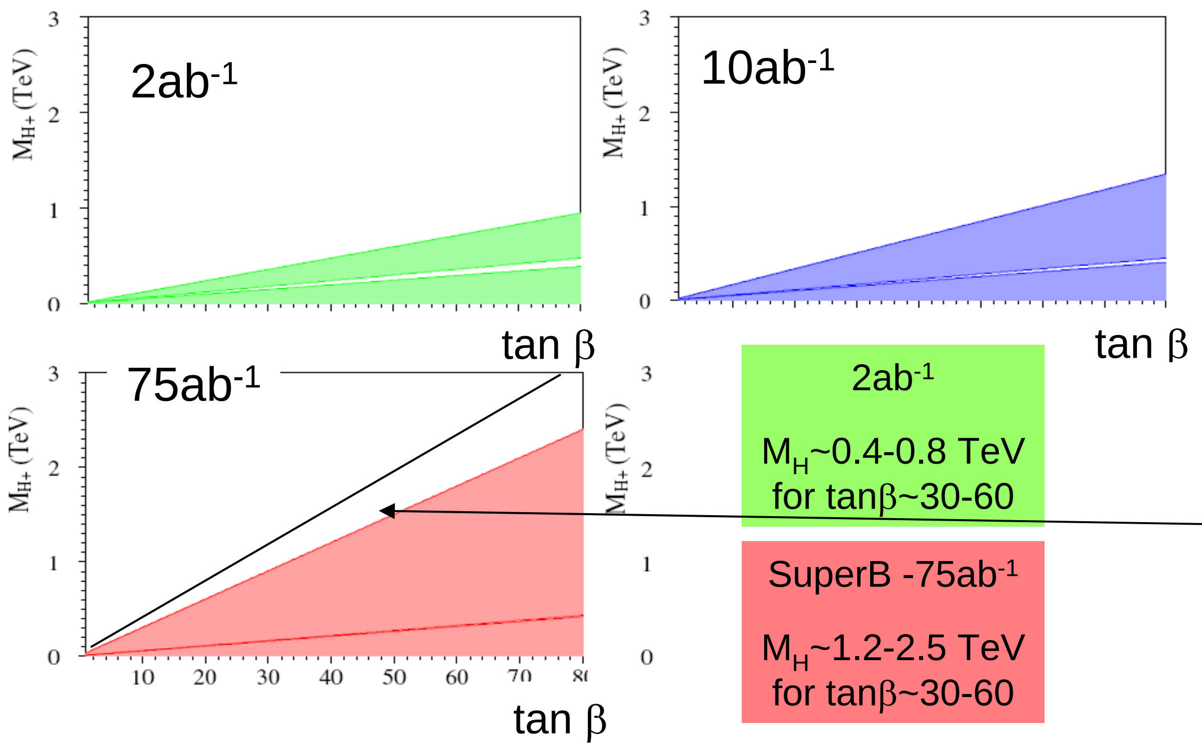
$$\mathrm{BR}(B\to\tau\nu)=\mathrm{BR}_{\mathrm{SM}}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$

Observable	B Factories ($2\ \mathrm{ab}^{-1}$)	**SuperB**
$\mathcal{B}(B\to\tau\nu)$	20%	4% (†)
$\mathcal{B}(B\to\mu\nu)$	visible	5%
$\mathcal{B}(B\to D\tau\nu)$	10%	2%

(+) systematically limited (to be studied with the improved detector)

Br(B→τν) 4% (below limited by systematics)
..probably not with improved detector.

Br(B→μν) can be measured with the same precision
not limited by syst.



This analysis has be redone
and to see how far we can
go in precision.

$2\mathrm{ab}^{-1}$

M_H~0.4-0.8 TeV
for tanβ~30-60

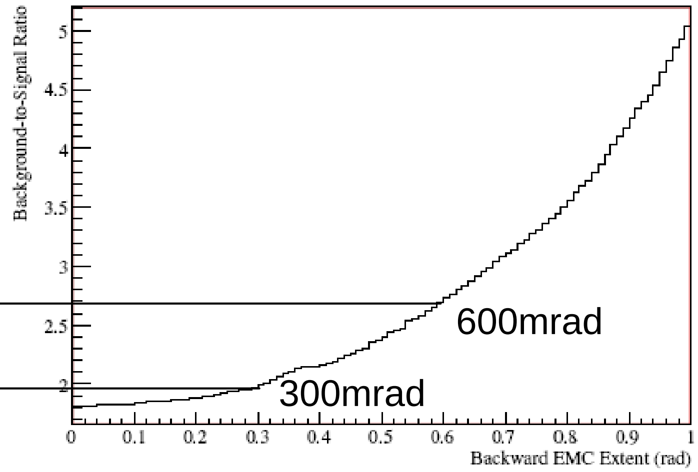
SuperB -$75\mathrm{ab}^{-1}$

M_H~1.2-2.5 TeV
for tanβ~30-60

σ(BR) (2-3)%
impressive impact

Background Processes to $B \rightarrow \tau\nu$

Process	BF	Relative to signal	
$B^+ \rightarrow \pi^0 l\nu$	7.4×10^{-5}	3x	Lose one or both photons
$B^+ \rightarrow \rho^0 l\nu$	1.2×10^{-4}	5x	Lose two charged pions
$B^0 \rightarrow \pi^+ l\nu$	1.4×10^{-4}	5x	Lose pion, misreconstruct tag charge
$B^0 \rightarrow \rho^+ l\nu$	2.3×10^{-4}	10x	Lose pion, one or two photons, misreco tag
$B^+ \rightarrow D^0 l\nu$	2.2×10^{-2}	900 x (!!!)	Lose all decay products of the D
... $D^0 \rightarrow K\pi$	3.8%	33x	Lose K,π
... $D^0 \rightarrow K_L \pi^0$	1.1%	10x	Lose K_L, one or both photons
... $D^0 \rightarrow K_S \pi^0$	1.1%	10x	Lose K_S, one or both photons
... $D^0 \rightarrow 0$ Prong	19.0%	150x	Lose some or all neutrals



B/N 2.8→2

600mrad

300mrad

Figure 7.2: *Background over signal ratio for the $B \rightarrow \tau\nu$ search in the hadronic recoil as a function of the backward extent of the EMC. The energy resolution is degraded below 700 mrad to simulate the performance of a veto device.*

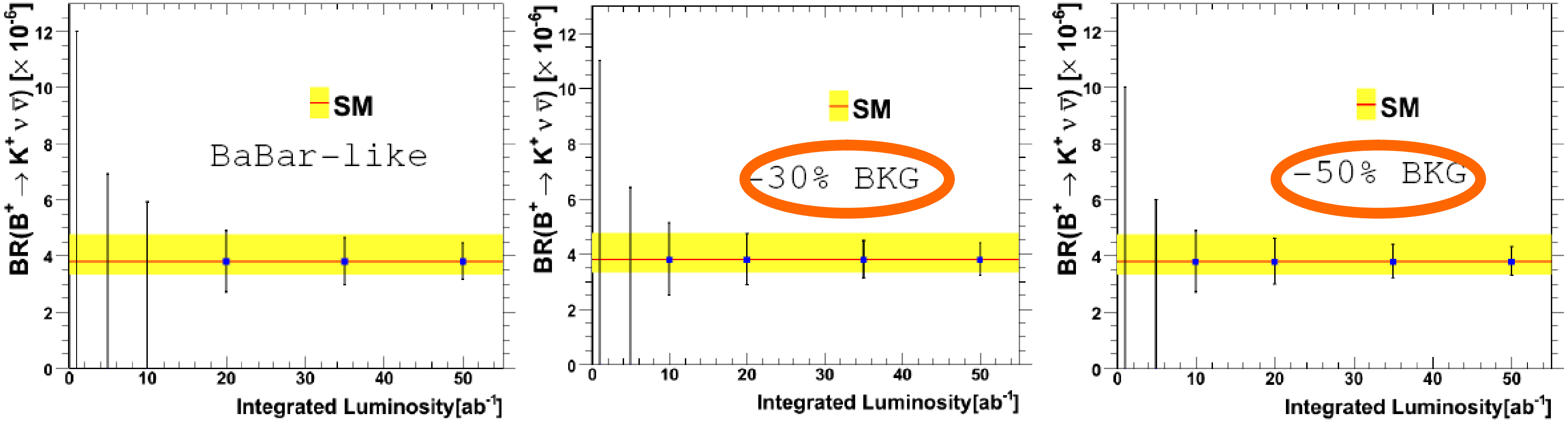
$B^+ \rightarrow K^+ \nu \nu$

from Francesco Renga

- Recoil Technique (both HAD and SL);
- Kinematics: cut on the K CM momentum;
- Cut-and-count technique;

EXPECTED YIELDS PER ab^{-1}

SL RECOIL	HAD RECOIL
$N_{\mathrm{sig}} = 6.4 \quad (\varepsilon = 0.00164)$	$N_{\mathrm{sig}} = 2.6 \quad (\varepsilon = 0.000678)$
$N_{\mathrm{bkg}} = 84$	$N_{\mathrm{bkg}} = 60$



Reduction of the background → make the observation possible with 10ab^{-1} instead of 20ab^{-1}..

The physics case of reducing the background is there.

Is it realistic ?

Hermiticity :

→Helps to reduce the background when applying a cut on track multiplicity in the recoil 30% of background is realistic ?

→ Modify the distribution of Eextra

Vertexing :

→Vertex information not really used at present

→backg. Reduction is possible applying vertexing requirements and secondary vertex informations

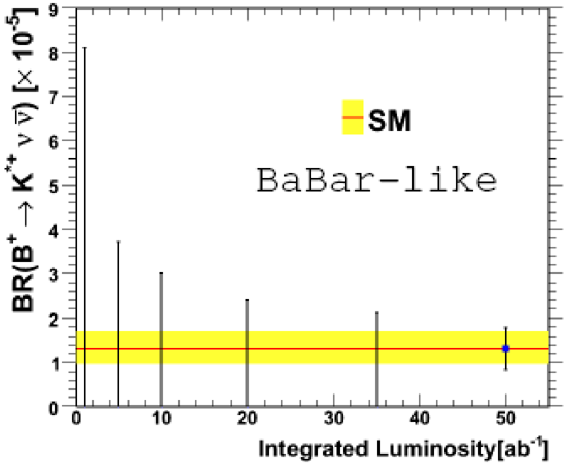
Other:

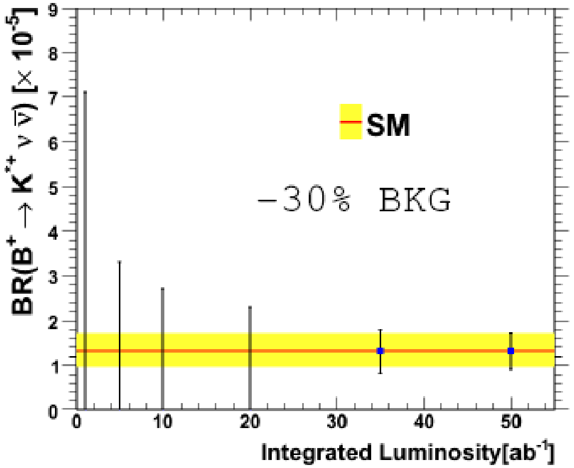
→PID (mainly for K* analysis), KL vetos…

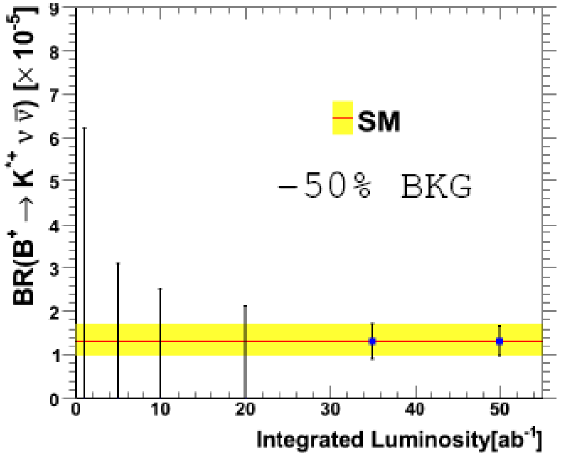
$B^+ \to K^{*+} \nu \nu$ (I)

EXPECTED YIELDS PER ab^{-1}

K*+ channel	SL RECOIL	HAD RECOIL
$K_S^0\pi^+$	$N_{\rm sig} = 6 \quad (\varepsilon = 0.0004205)$ $N_{\rm bkg} = 2057$	$N_{\rm sig} = 1 \quad (\varepsilon = 0.0000695)$ $N_{\rm bkg} = 19$
$K^+\pi^0$	$N_{\rm sig} = 8.5 \quad (\varepsilon = 0.0005950)$ $N_{\rm bkg} = 2171$	$N_{\rm sig} = 1.4 \quad (\varepsilon = 0.0000993)$ $N_{\rm bkg} = 31$







B physics @ U(4S)

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\sin(2\beta)$ (Dh^0)	0.10	0.02
$\cos(2\beta)$ (Dh^0)	0.20	0.04
$S(J/\psi\,\pi^0)$	0.10	0.02
$S(D^+D^-)$	0.20	0.03
α $(B \to \pi\pi)$	$\sim 16°$	$3°$
α $(B \to \rho\rho)$	$\sim 7°$	1–$2°$ $(*)$
α (combined)	$\sim 6°$	1–$2°$ $(*)$
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
$S(K^0_SK^0_SK^0_S)$	0.15	0.02 $(*)$
$S(K^0_S\pi^0)$	0.15	0.02 $(*)$
$S(\omega K^0_S)$	0.17	0.03 $(*)$
$S(f_0K^0_S)$	0.12	0.02 $(*)$

$\lvert V_{cb}\rvert$ (exclusive)	4% $(*)$	1.0% $(*)$
$\lvert V_{cb}\rvert$ (inclusive)	1% $(*)$	0.5% $(*)$
$\lvert V_{ub}\rvert$ (exclusive)	8% $(*)$	3.0% $(*)$
$\lvert V_{ub}\rvert$ (inclusive)	8% $(*)$	2.0% $(*)$

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%
$\mathcal{B}(B \to \rho\gamma)$	15%	3% (†)
$\mathcal{B}(B \to \omega\gamma)$	30%	5%
$A_{CP}(B \to \rho\gamma)$	~ 0.20	0.05
$A_{CP}(b \to s\gamma)$	0.012 (†)	0.004 (†)
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.006 (†)
$S(K^0_S\pi^0\gamma)$	0.15	0.02 $(*)$
[redacted]	[redacted]	[redacted]
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\overline{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

Possible also at LHCb

Similar precision at LHCb

τ physics

Process	Sensitivity
$\mathcal{B}(\tau \to \mu\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\gamma)$	2×10^{-9}
[redacted]	[redacted]
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_s)$	2×10^{-10}

Charm at U(4S) and threshold

Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
$D^0 \to K^0_S\pi^+\pi^-$	x'^2_D	$1–2 \times 10^{-4}$	3×10^{-5}
	y_D	$2–3 \times 10^{-3}$	5×10^{-4}
	x_D	$2–3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1–2 \times 10^{-3}$	3×10^{-4}
	x_D	$2–3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	x'^2	*To be evaluated at LHCb*	3×10^{-5}
	y'		7×10^{-4}
$D^0 \to K^+K^-$	y_{CP}		5×10^{-4}
$D^0 \to K^0_S\pi^+\pi^-$	x		4.9×10^{-4}
	y		3.5×10^{-4}
	$\lvert q/p \rvert$		3×10^{-2}
	ϕ		2°

Channel	Sensitivity
[redacted]	[redacted]
$D^0 \to \pi^0 e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_s e^+e^-$, $D^0 \to K^0_s\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
[redacted]	[redacted]
[redacted]	[redacted]
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K^0_s e^\pm\mu^\mp$	3×10^{-8}
[redacted]	[redacted]
[redacted]	[redacted]
[redacted]	[redacted]

B_s at U(5S)

Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
$A^s_{\rm SL}$	0.006	0.004
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
$\lvert V_{td}/V_{ts} \rvert$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
[redacted]	[redacted]	[redacted]
β_s from $B_s \to K^0\bar{K}^0$	24°	11°